F7 and FORCLIMIT PROJECTS:

The Tropical Forestry and Global Climate Change Research Network

Climate Change Mitigation: Role of Forests and Forestry Projects

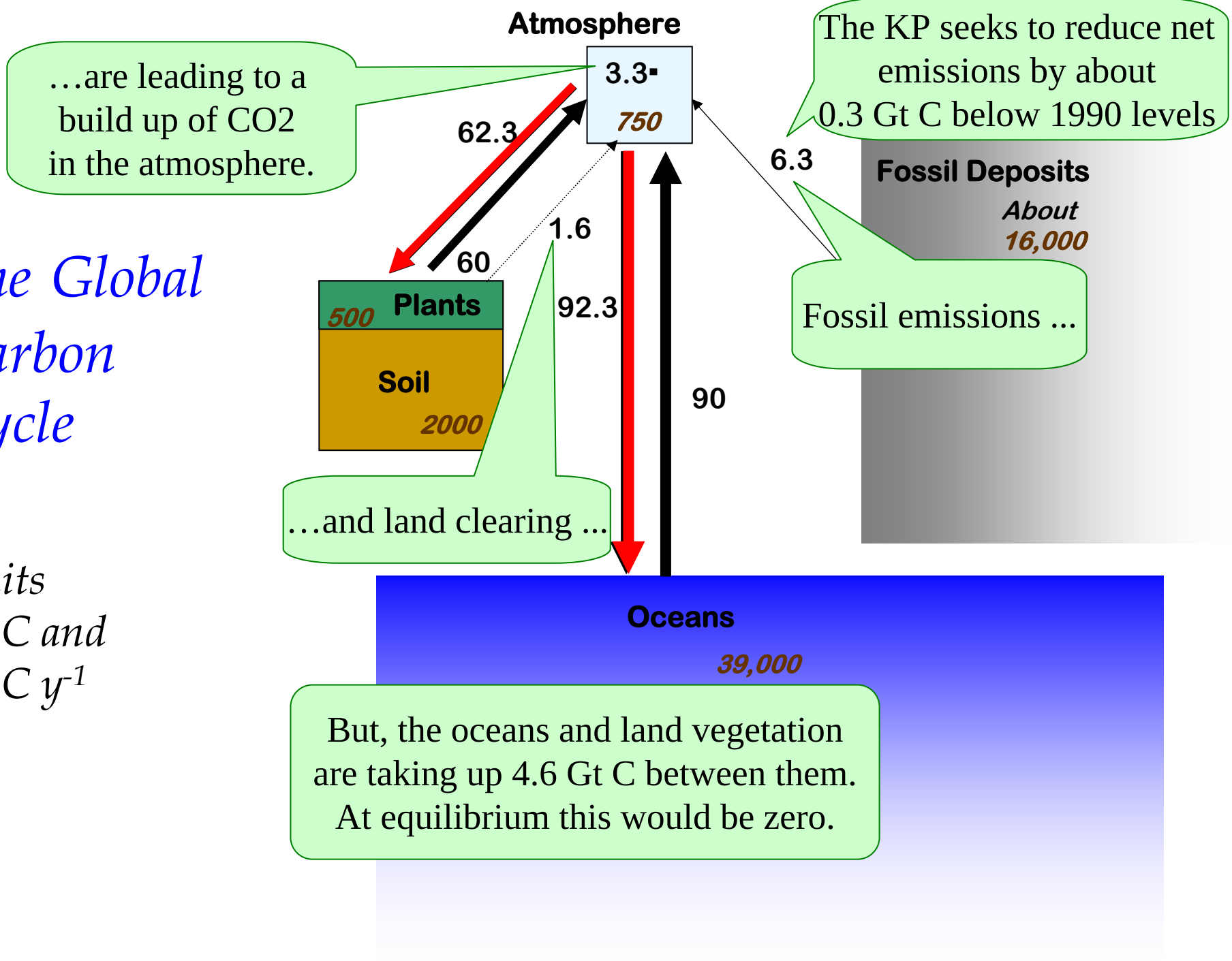
Jayant Sathaye
Lawrence Berkeley National Laboratory (Berkeley Lab)
University of California, Berkeley, CA

July 2003

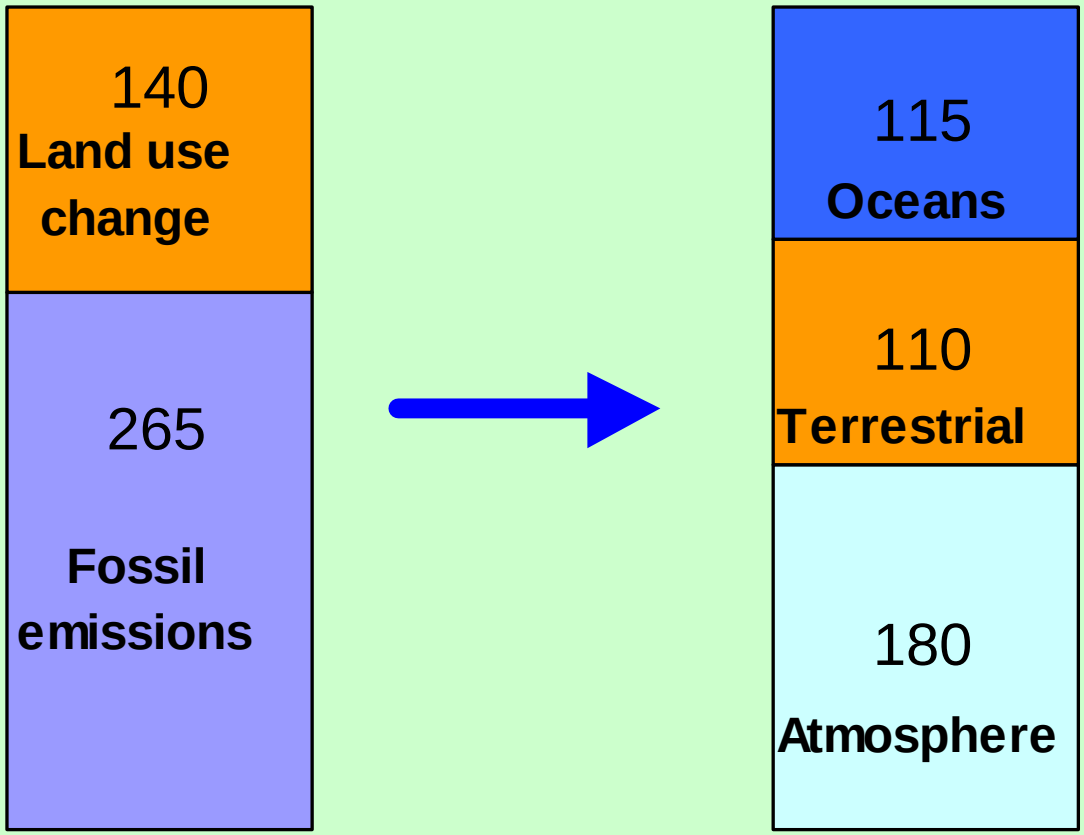
What is the role of sinks in the global carbon cycle?

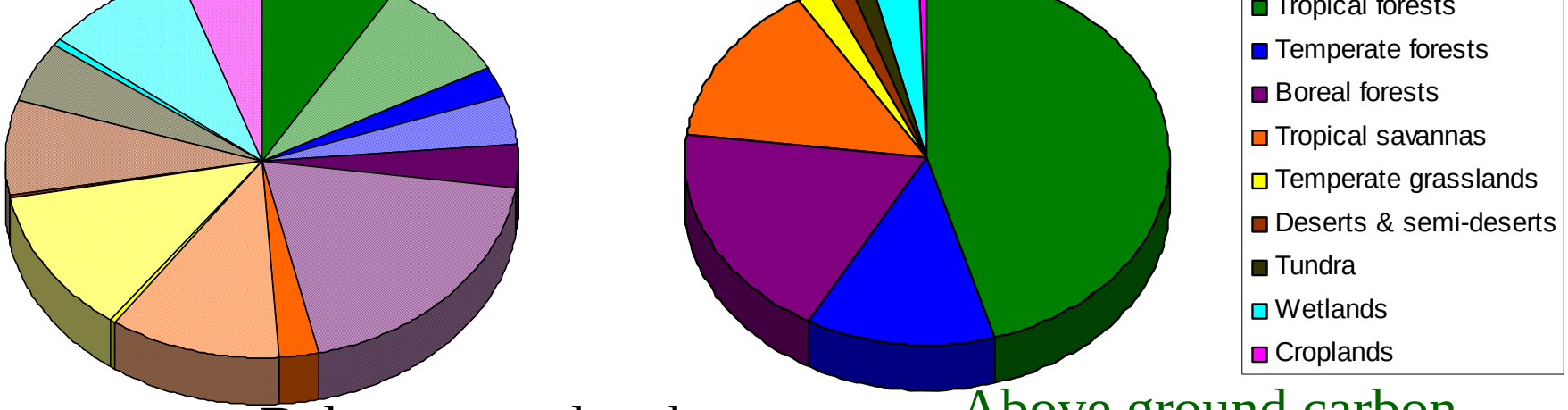
The Global Carbon Cycle

Units
Gt C and
Gt C y^{-1}



Carbon emissions and uptakes since 1800 (Gt C)





Below ground carbon

Above ground carbon

***Table 1**: Global carbon stocks in vegetation and soil carbon pools down to a depth of 1 m.*

Biome	**Area (10^9 ha)**	**Global Carbon Stocks (Gt C)**		
		Vegetation	**Soil**	**Total**
Tropical forests	1.76	212	216	428
Temperate forests	1.04	59	100	159
Boreal forests	1.37	88	471	559
Tropical savannas	2.25	66	264	330
Temperate grasslands	1.25	9	295	304
Deserts & semi-deserts	4.55	8	191	199
Tundra	0.95	6	121	127
Wetlands	0.35	15	225	240
Croplands	1.60	3	128	131
World total	15.16	466	2011	2477

What is the forestry mitigation potential in developing countries?

Mitigation Analysis

- **Goal:**
  - **Estimate the carbon mitigation potential and costs of forestry options**
- **Scale:**
  - **National or regional level analysis**
  - **Project-specific analysis**
    - Confined to a specific geographic location, time period and institutional framework so as to allow changes in GHG emissions attributable to the project to be monitored and verified

F7 Project Description

- **National and regional level mitigation analysis**
- **Studies conducted by country-specific modeling teams**
  - **LBNL provides technical support, training and outreach**
- **All analyses use the same model**
  - **COMAP accounting approach**
- **Data: National statistics on land use patterns, carbon benefits and costs of mitigation options, timber and non-timber prices, etc.**

F7 and FORCLIMIT
Participating Research Groups (F7 since 1990)

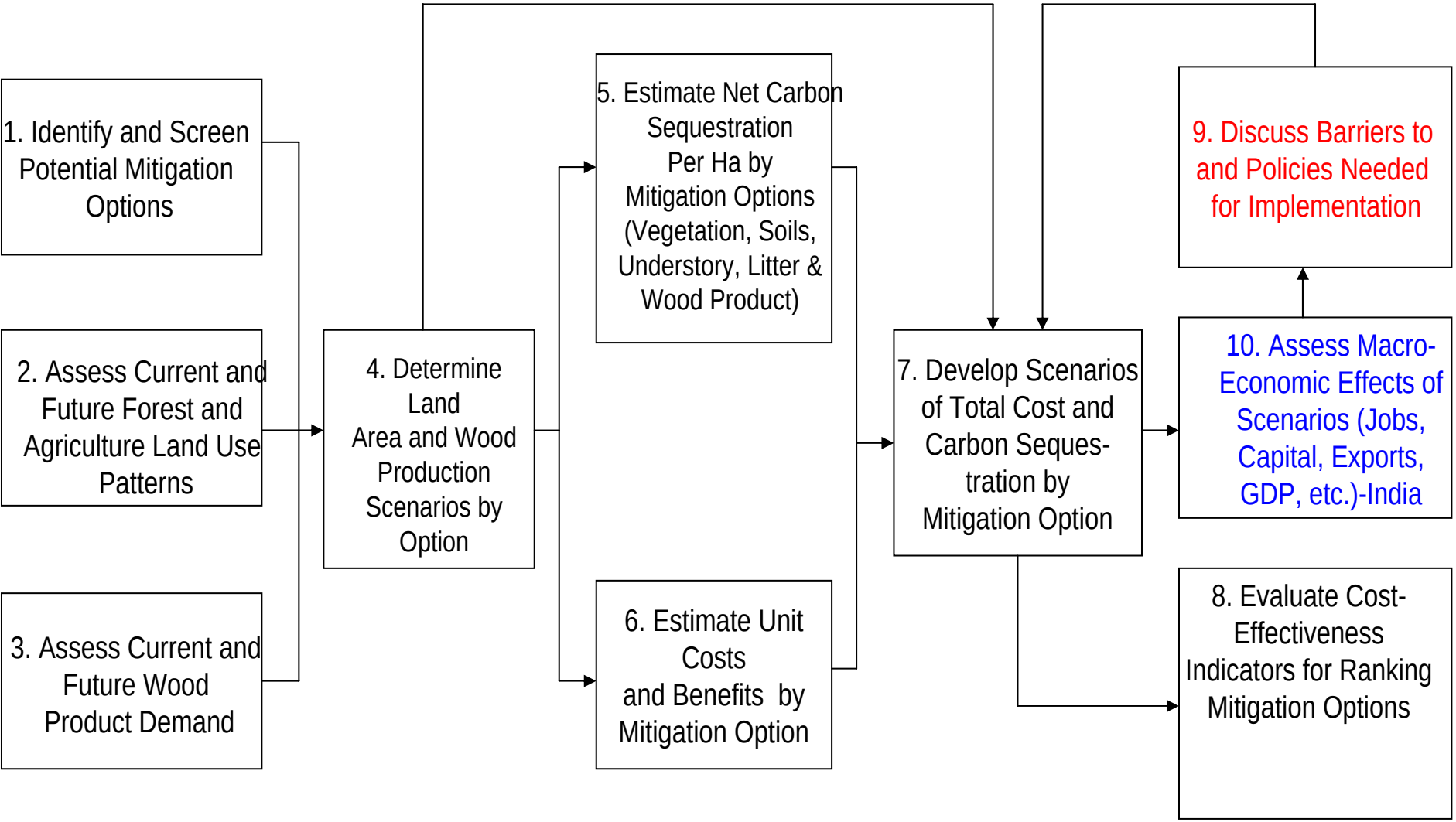
- ASIA:
  - CHINA -- Xu, Deying (IPCC Lead Author, LULUCF Report), Forest Ecology and Environment Institute, Beijing
  - INDIA -- Dr. N.H. Ravindranath (IPCC Coordinator, LULUCF Report, CLA for Tech Transfer, and LA for WGIII Report, Consultant to UNFCCC), Indian Institute of Science, Bangalore
  - INDONESIA -- Prof. Rizaldi Boer (UNFCCC Consultant), Bogor Agriculture University, Bogor (co-funding with EAP)
  - MALAYSIA -- Dr. Roslan Ismail (ITTO Board, IPCC LA), SustechAsia.com Sdn Bhd., and Prof. Azman Abidin, UPM, Malaysia (via EAP funding)
  - PHILIPPINES -- Prof. Rodel Lasco (IPCC Lead Author, LULUCF Report), University of the Philippines, Los Banos (via EAP funding)
- AFRICA:
  - TANZANIA -- (Yonika Ngaga, CEEST, Dar es Salam, and Dr.Willy Makundi, LBNL, LULUCF and WGIII Lead Author)
- LATIN AMERICA:
  - MEXICO -- Prof. Omar Masera, IPCC CLA LULUCF and LA Tech Transfer and WG III reports, National University of Mexico
  - BRAZIL -- Dr. Philip Fearnside, IPCC, CLA LULUCF and LA WGII, National Institute for Research in the Amazon (INPA), Manaus

Mitigation Analysis

Using a bottom-up approach

- Select area (country or region) and option to analyze
- Develop basecase and mitigation land-use scenarios by option
- Estimate carbon stock changes by option in each carbon pool
  - Live and dead biomass, soil, and products
- Estimate costs and benefits of each option
  - Costs: Investment, recurring, opportunity, and monitoring
  - Revenues: Timber, fuel wood, honey, etc. sources
- Compare cost and carbon estimates
  - Use an equilibrium carbon approach, and/or track annual changes in carbon and costs/benefits
- Estimate macroeconomic impacts

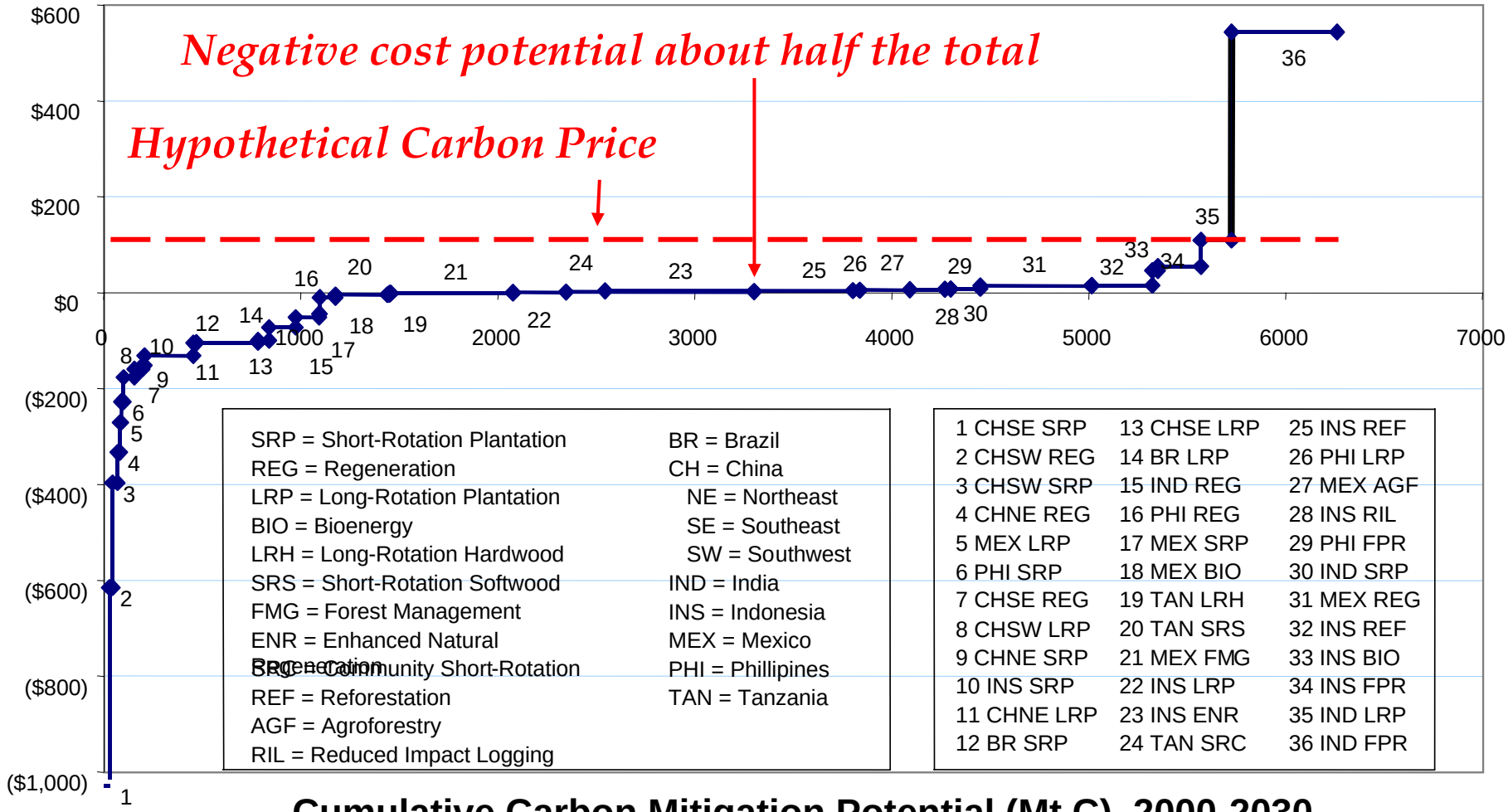
Comprehensive Mitigation Analysis Process (COMAP)



COMAP: Forestry Mitigation Potential

(Brazil, China, India, Indonesia, Mexico, Philippines and Tanzania)

Cost ($/ t C) DR = 8-12%



Cumulative Carbon Mitigation Potential (Mt C), 2000-2030

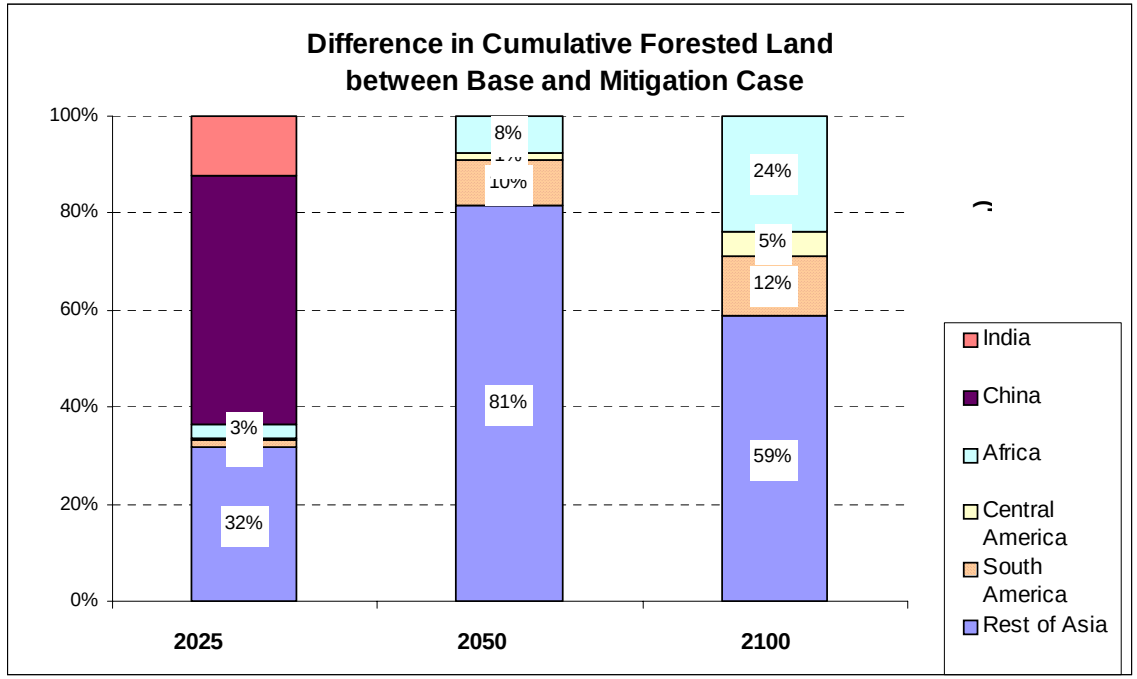
Source: 1. Sathaye J. Makundi W., Andrasko K. Boer R., Ravindranath N.H., Sudha P., Rao S., Lasco R., Pulhin F., Masera O., Ceron A., Ordonez J., Deying X., Zhang X., and Zuomin S. 2001. Carbon mitigation potential and costs of forestry options in Brazil, China, India, Indonesia, Mexico, the Philippi and Tanzania. *Mitigation and Adaptation Strategies for Global Change,* Vol. 6. Nos. 3-4, pp. 185-211.

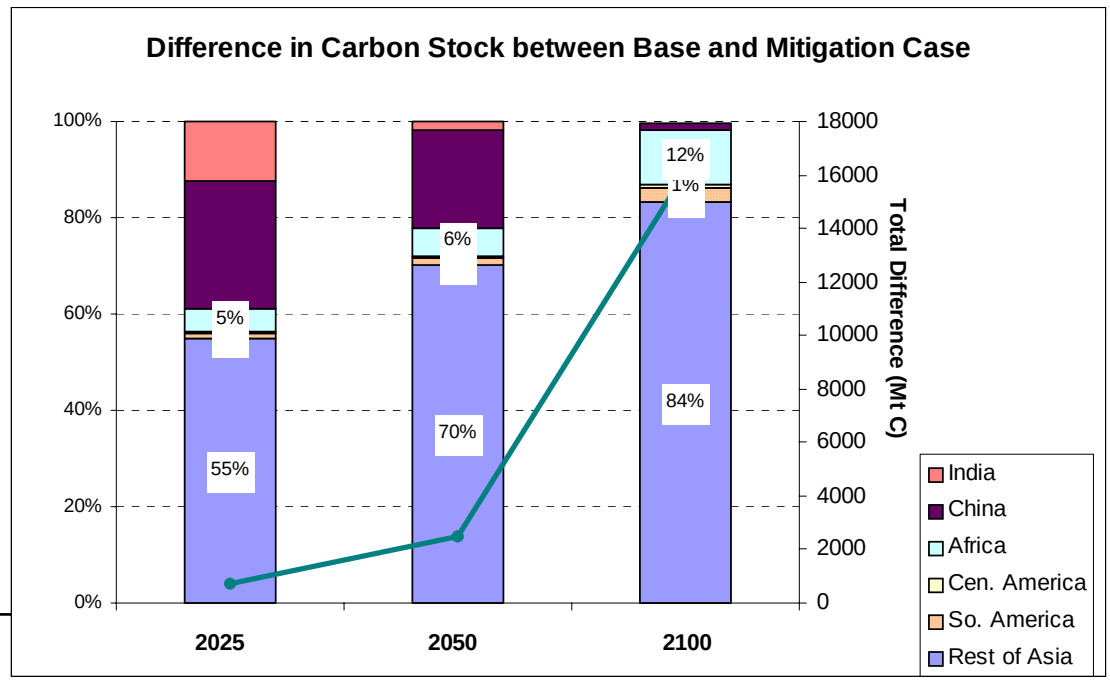
GCOMAP Results:

Forestation – Long Rotation: $10 / t C + 5 % / year carbon price scenario

1990-2000 FAO Base Case Planting Rates (thousand ha/yr):

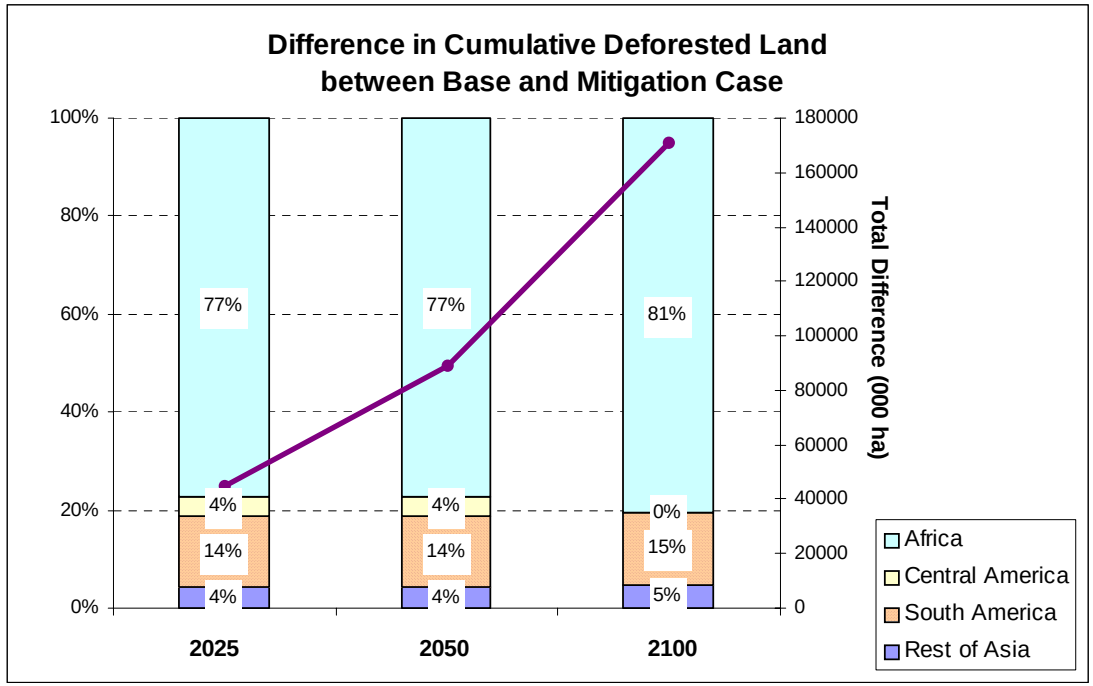
C America – 60
S America -- 80
Africa – 115
India – 350
China – 615
Rest of Asia – 1100

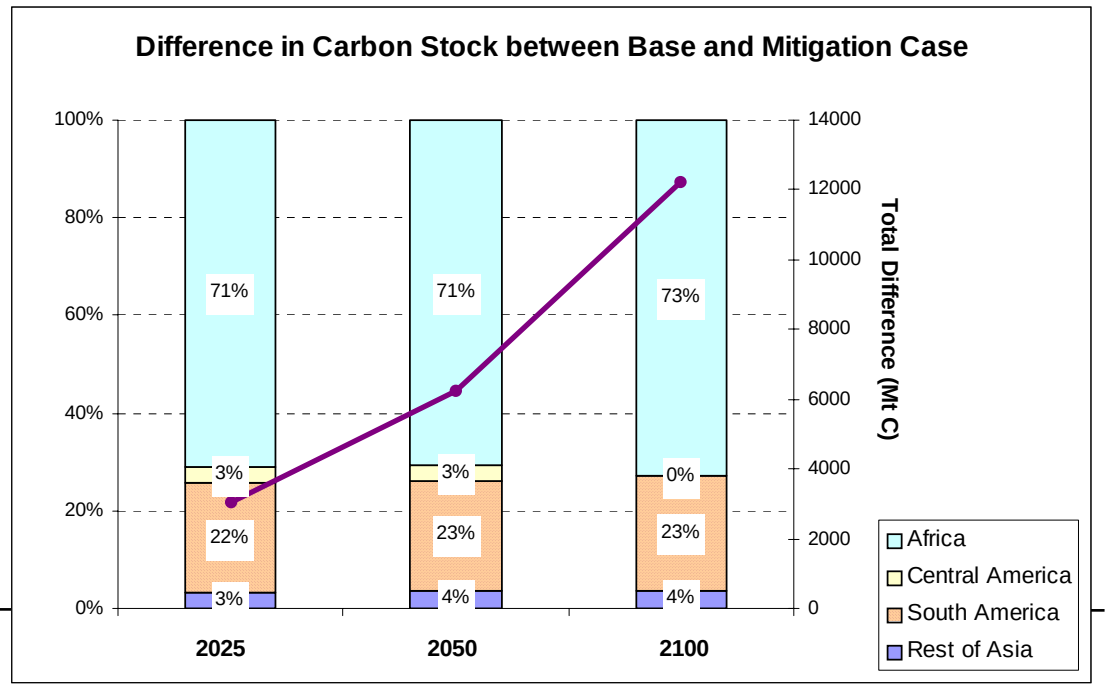




GCOMAP Results:

Avoided Deforestation: $10 / t C constant carbon price scenario

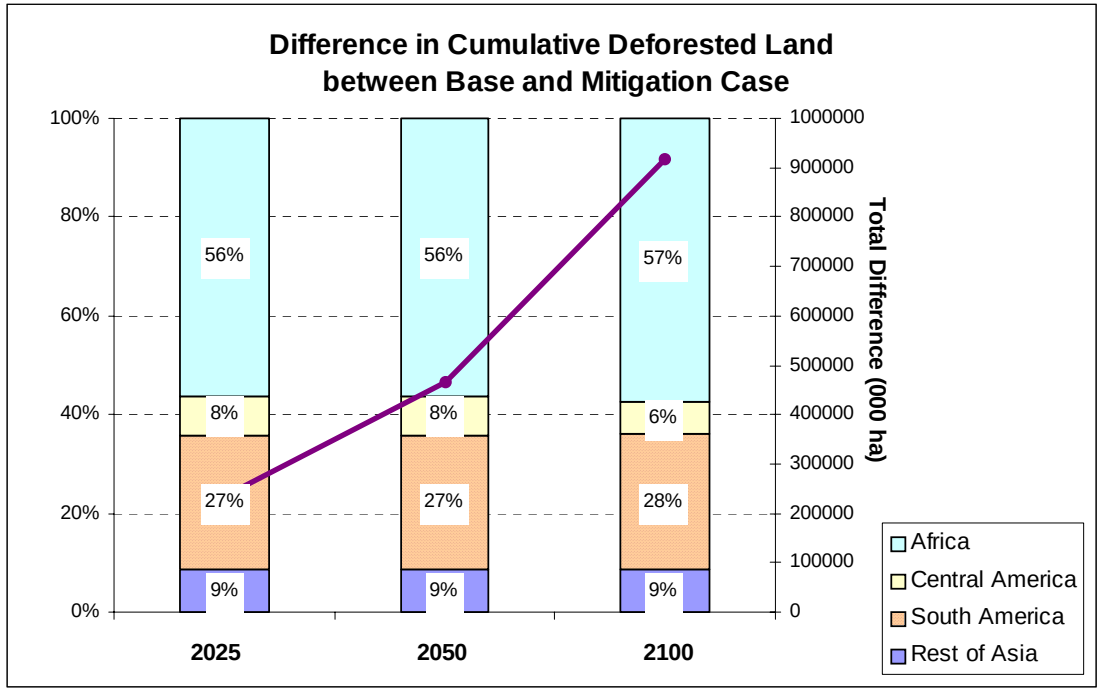


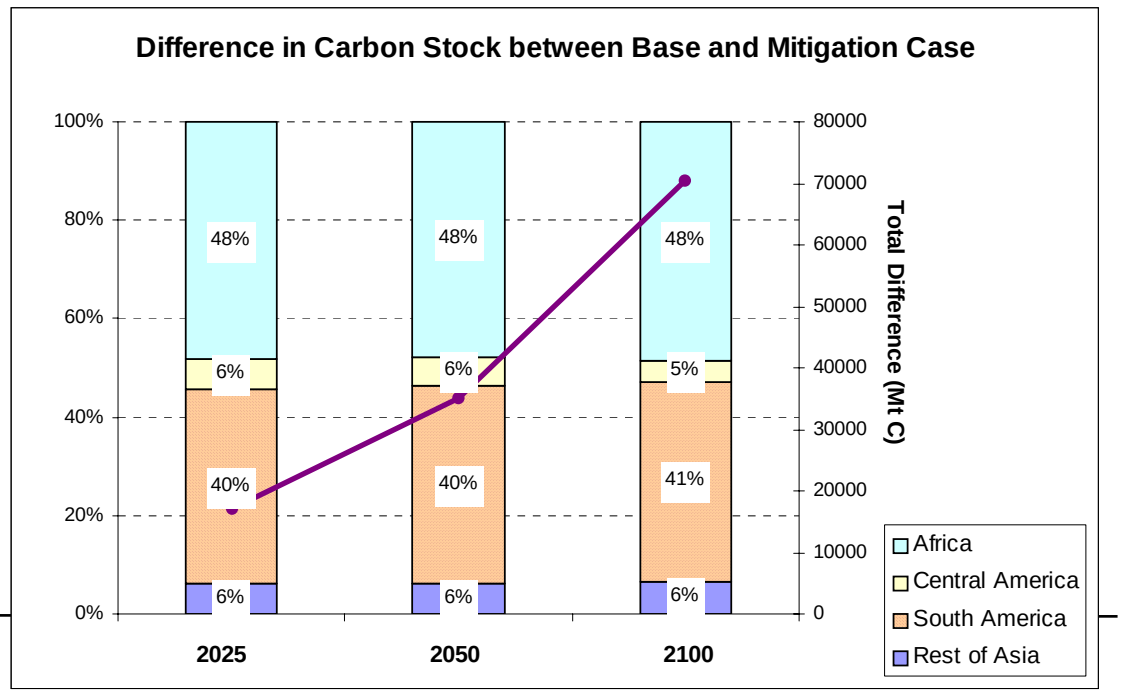


GCOMAP Results: Avoided Deforestation: $100 / t C constant carbon price scenario

Carbon price that halts deforestation:
Africa $ 38 / t C
C America $ 85 / t C
Rest of Asia $105 / t C
S America $ 85 / t C

Note: Prices are sensitive to the proportion of deforestation that yields timber revenue





1. Selection and Characterization of Options

- **Mitigation Options**
  - **Regeneration – Natural and Enhanced**
  - **Short and Long-rotation Plantations**
  - **Agroforestry**
  - **Forest Protection**
  - **Forest management**
  - **Bioenergy**
  - **Avoided deforestation**
- **Characteristics**
  - **Mean annual increment, soil carbon, vegetation carbon, rotation period**
  - **Establishment and silvicultural costs, timber and non-timber benefits**

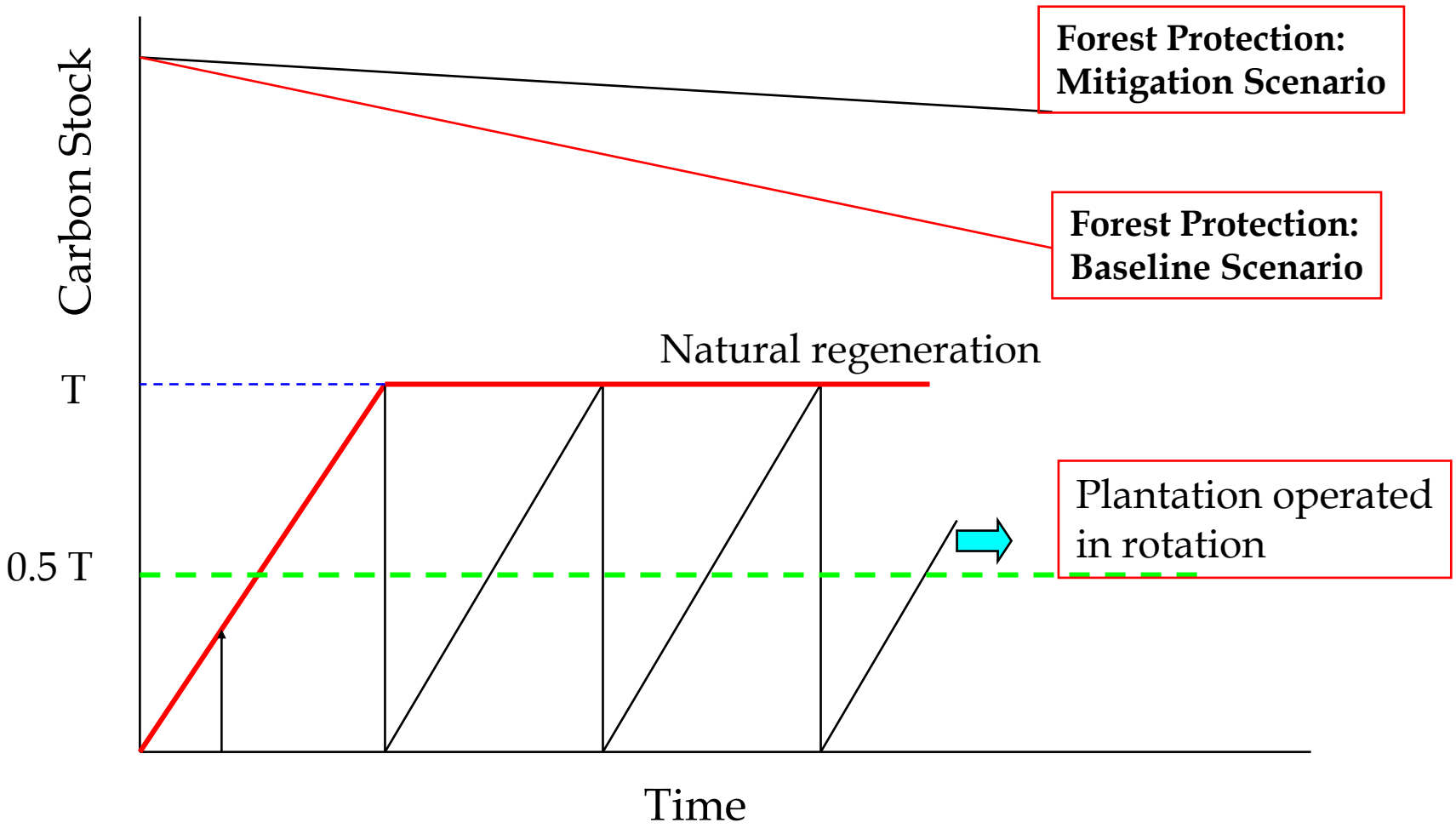
2. Land-use Scenarios

- Brazil -- Scenarios based on potential identified in literature
- China -- Two scenarios based on government plans
  - » Forestation of 80% and 60% of suitable land area in 30 years in three regions -- South West, South East, and North East.
- India -- Sustainable and commercial forestry scenarios analyzed
- Indonesia -- Government plans scenario, and a mitigation scenario were analyzed. The latter meets all wood demand by 2010.
- Philippines -- Forestation rates of 100% and 50% of government plans in two scenarios.
- Mexico -- Baseline (likely trends) and mitigation scenario analyzed
  - ❖ Mitigation consists of reduced deforestation rates, better forest management, and plantations meet commercial wood demand
- Tanzania - The Tropical Forest Action Plan (TFAP) scenario, assuming that 3.5 Mha and 1.7 Mha land area is converted are analyzed.

3. Carbon Accounting

- Four carbon pools are accounted for
  - Above- and below-ground biomass, detritus, soils and products
  - Carbon accounting is on an equilibrium value basis
- Annual balance is reported for vegetation carbon
- All accounting is with respect to a reference case or baseline carbon

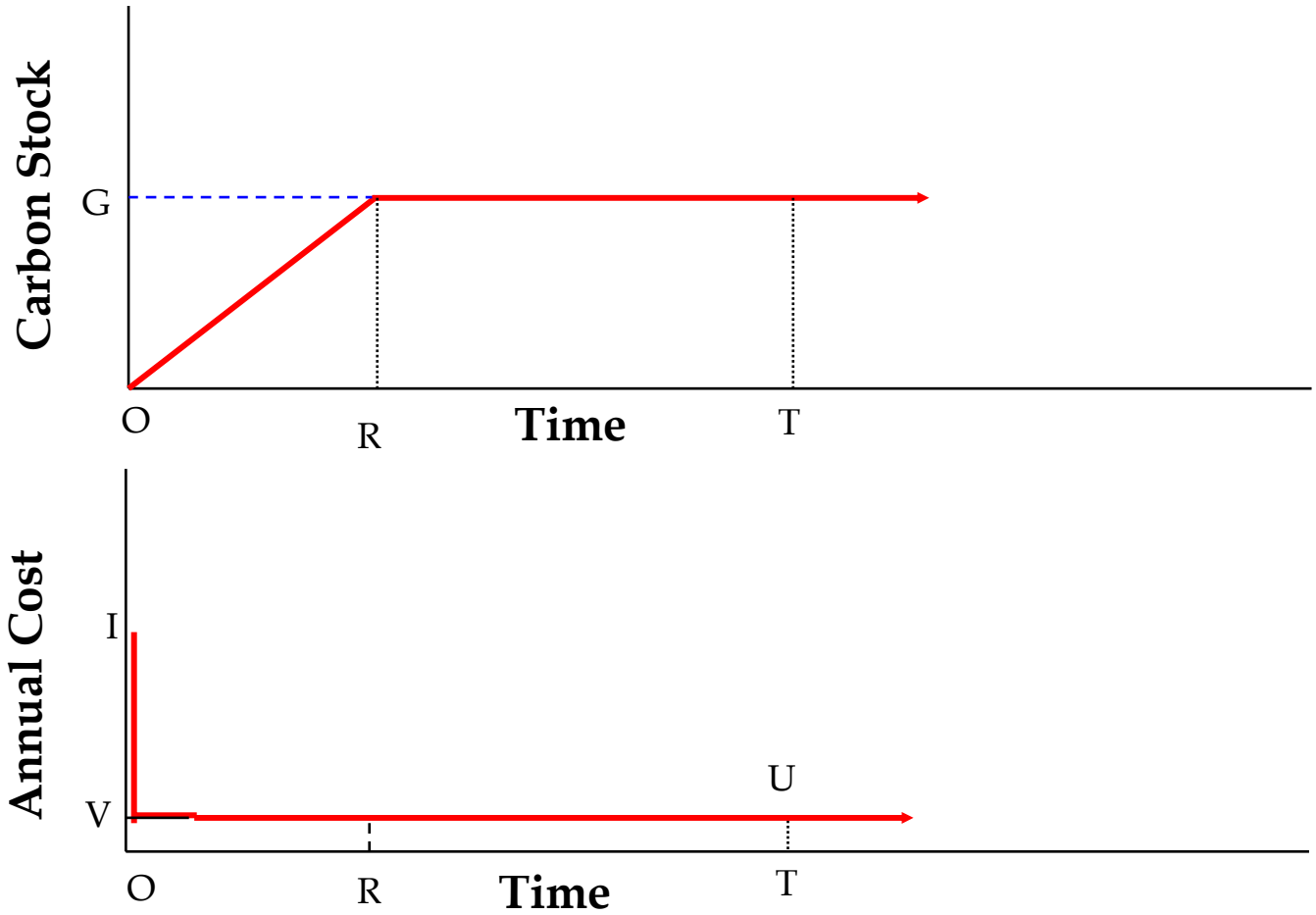
3.1 Carbon Accounting



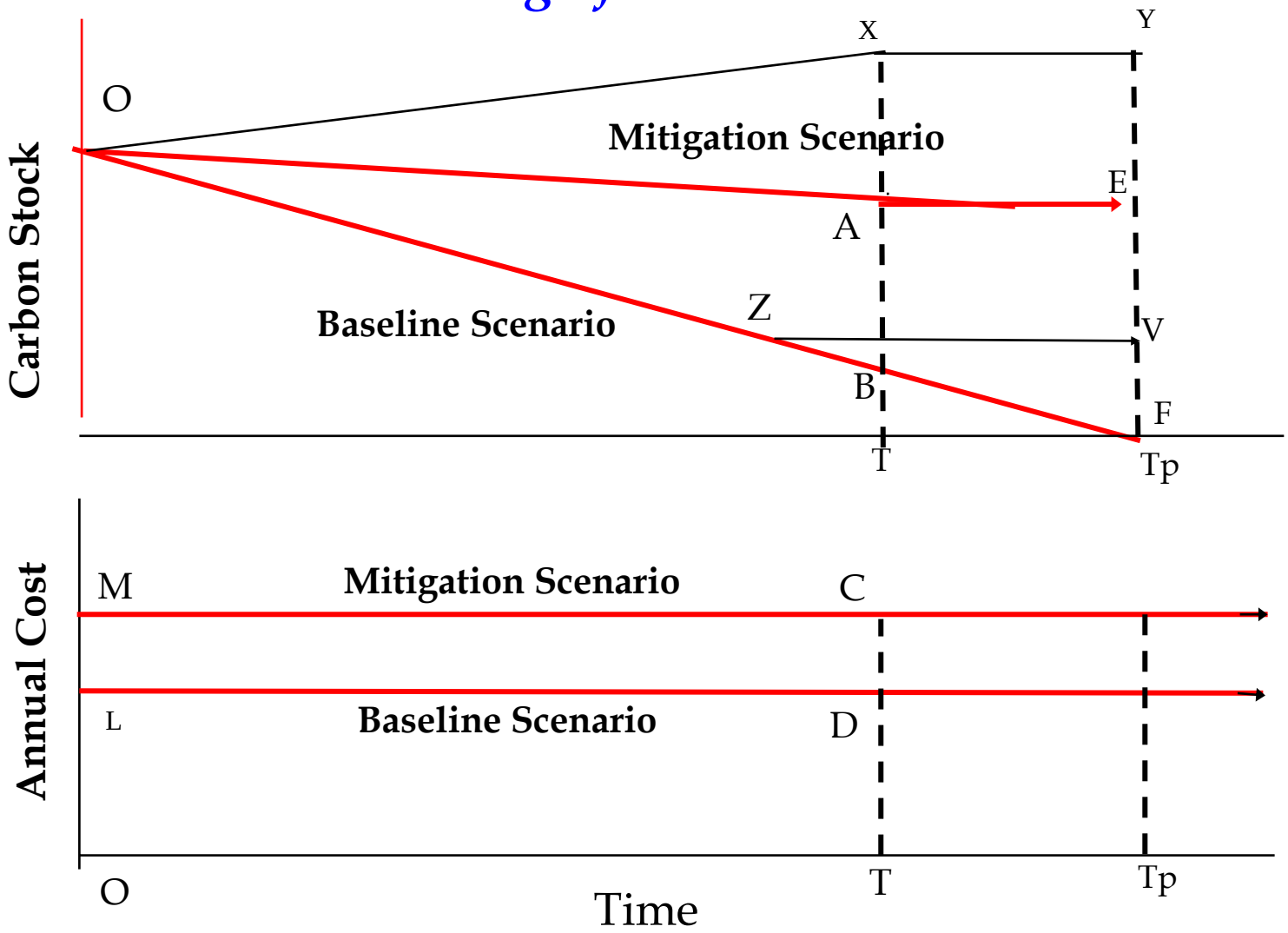
4. Benefit / Cost Accounting

- Costs include
  - Establishment or first costs
  - Recurring costs -- maintenance and monitoring
  - Opportunity cost of land
- Benefits include
  - Revenue from sale of timber and non-timber products -- fruits, honey, etc.
- Accounting is with respect to a reference case or baseline cost and benefits

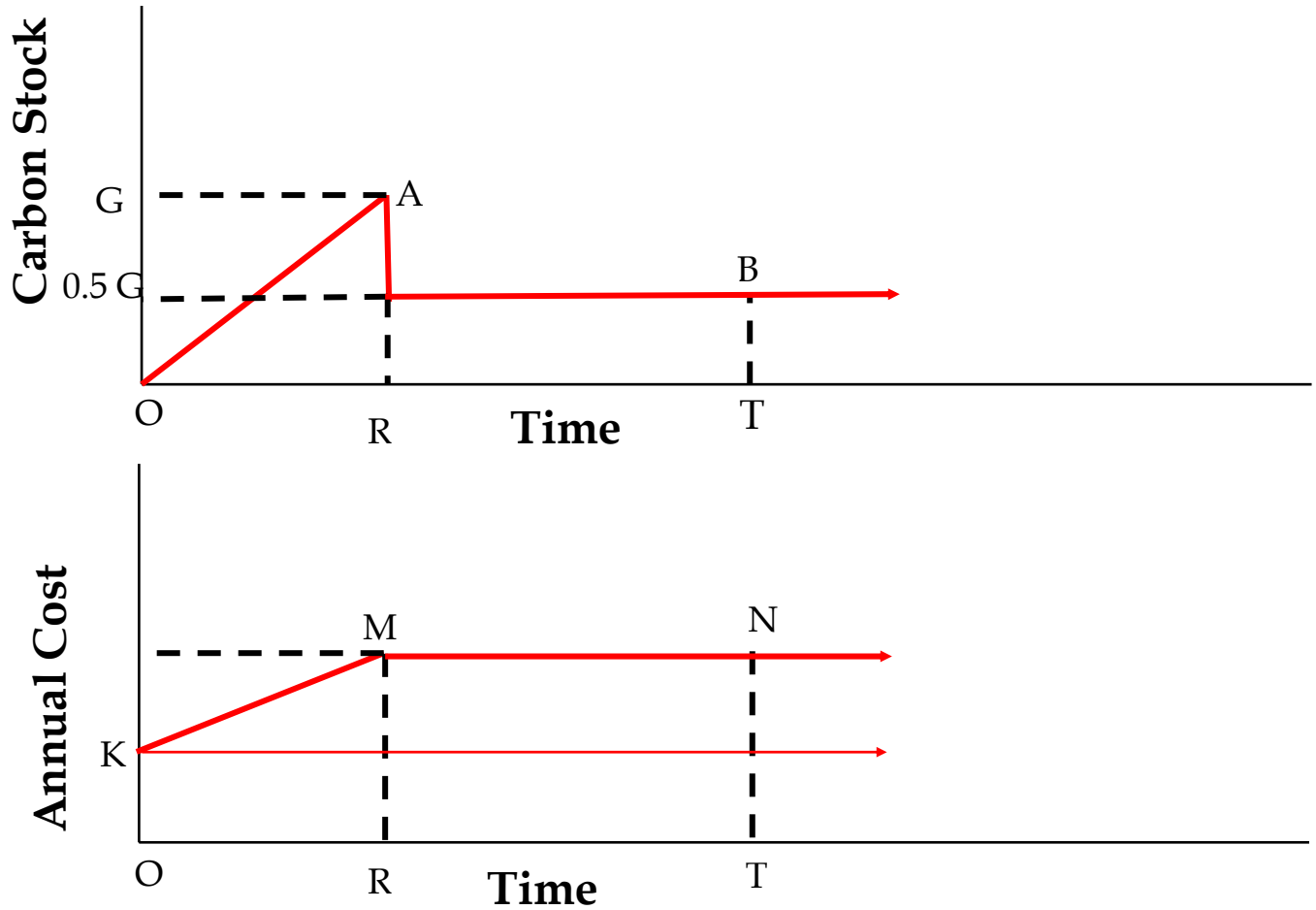
4.1 -- Regeneration Project: Accounting of Carbon and Costs



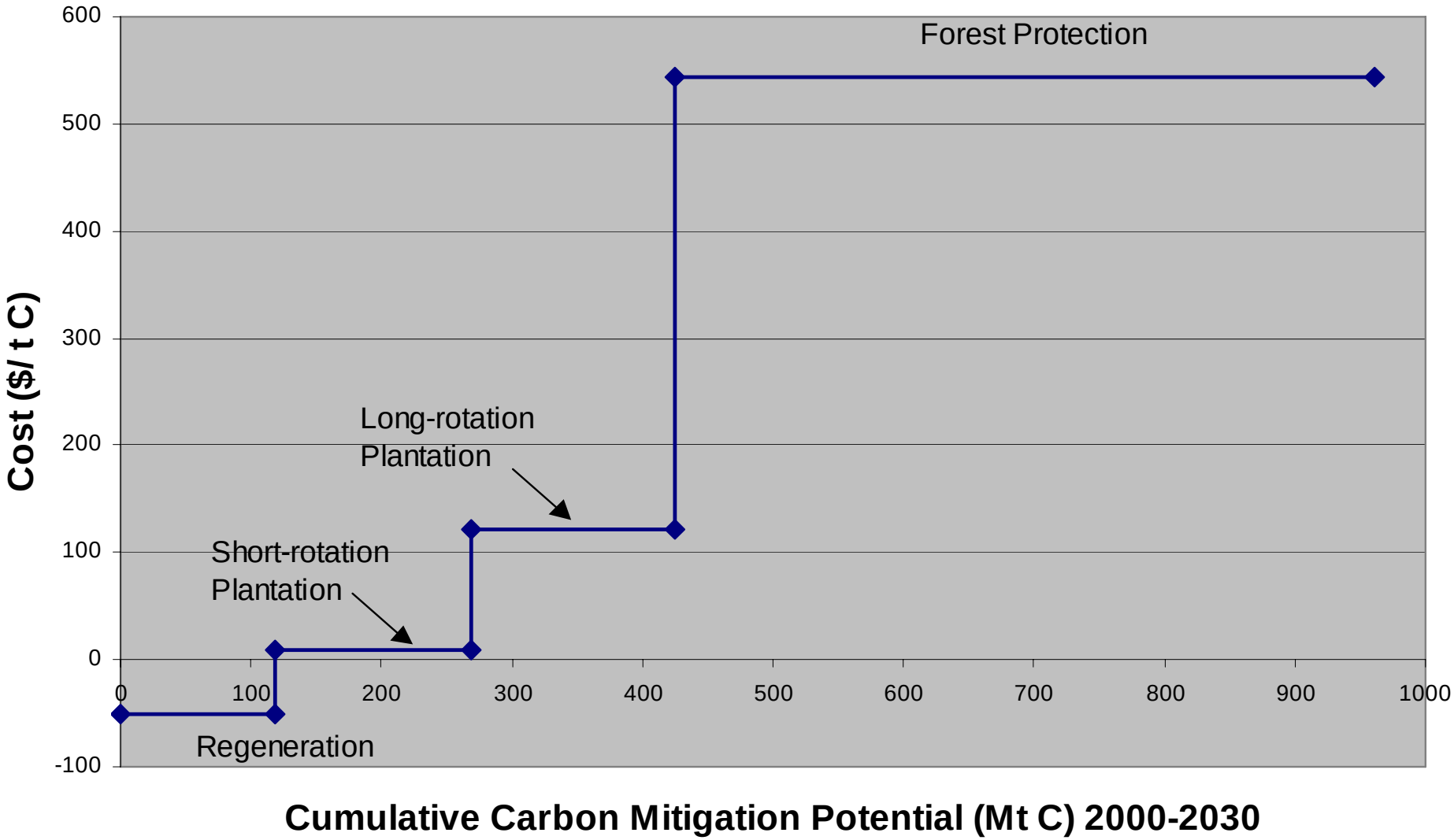
4.2 -- Forest Conservation Project: Accounting of Carbon and Costs



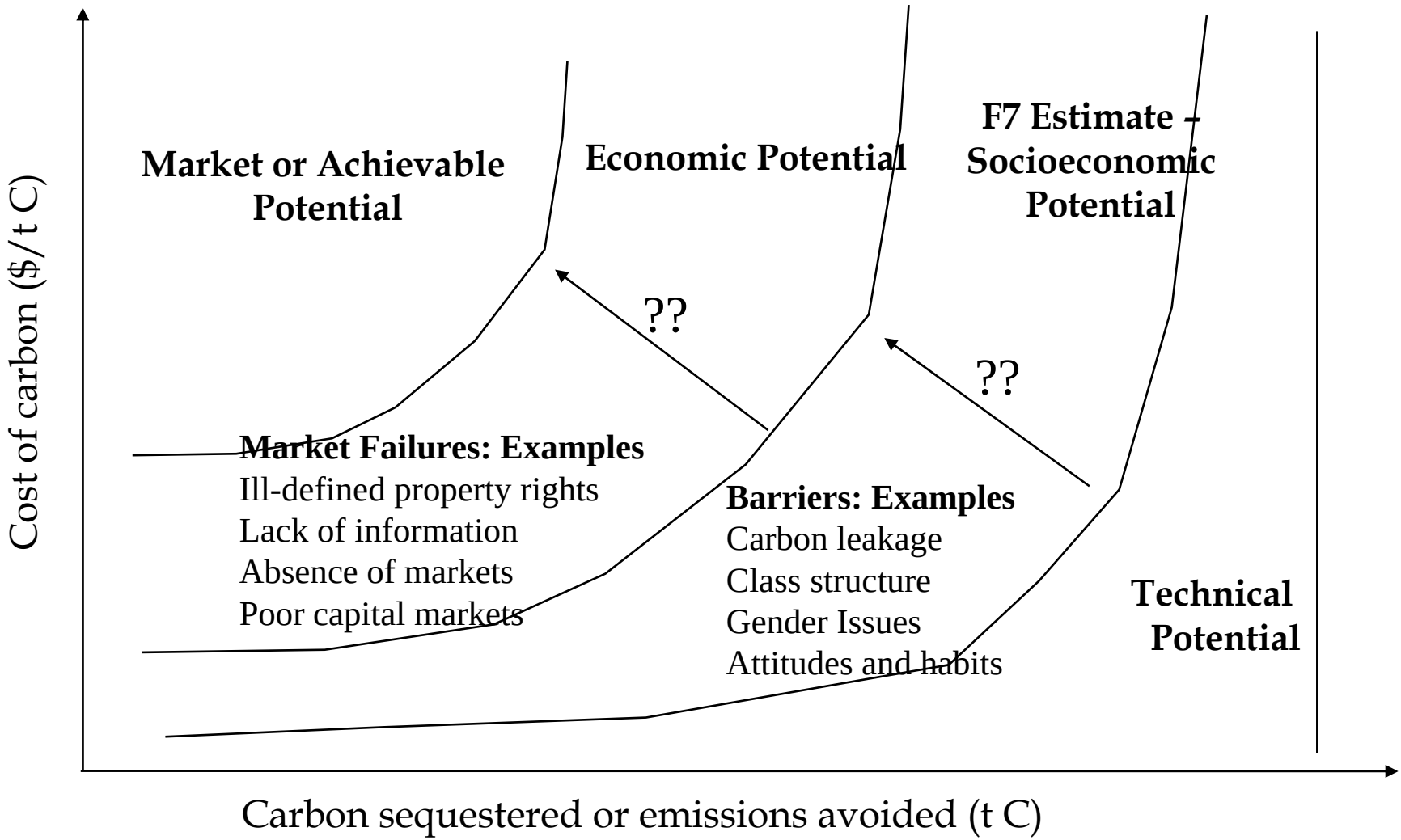
4.3 -- Plantation Project Harvested in Rotation: Accounting of Carbon and Costs



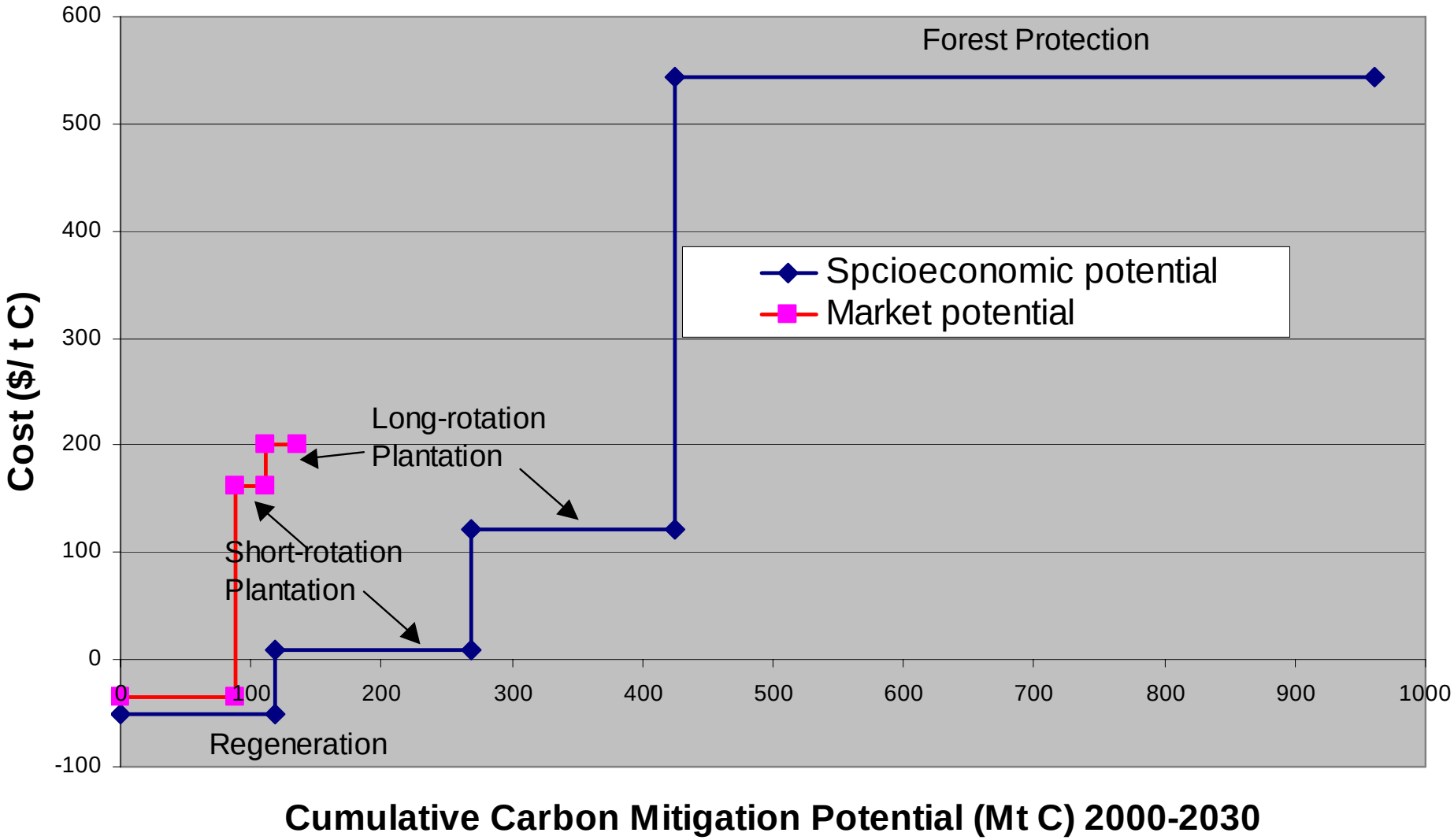
Forestry Mitigation Options, India



6. Conceptual Figure: Impact of barriers on costs and carbon mitigation potential



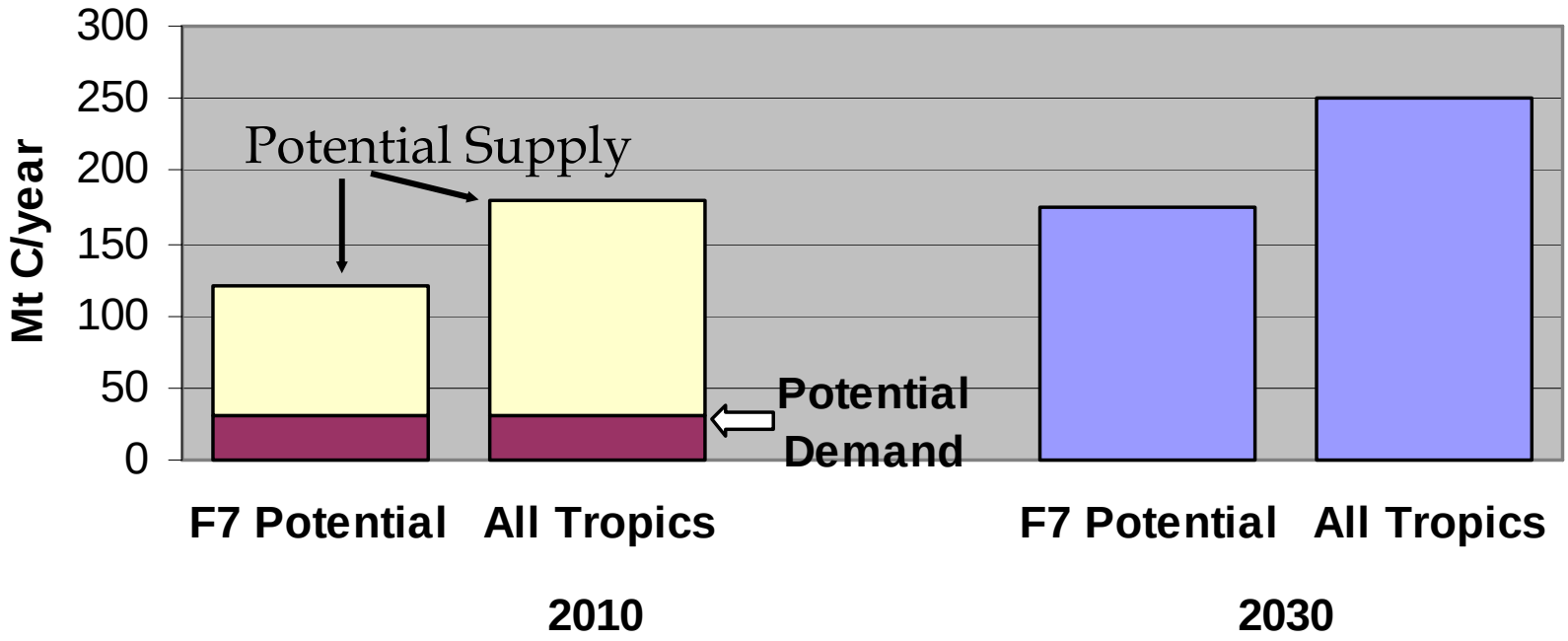
Forestry Mitigation Options, India



Carbon Benefits: Mitigation Options in F7 Studies

	2000-2012		2000-2030	
	Cumulative (Mt C)	**Annual average (Mt C/yr)**	**Cumulative (Mt C)**	**Annual average (Mt C/yr)**
F7 Study	**1,851**	**140**	**6199**	**200**
All-Tropics	**2,730**	**210**	**9,028**	**290**

Potential Tropical Carbon Supply and Demand
Forestation Activites



Ongoing Work at Berkeley Lab

- Estimating mitigation potential of projects taking barriers into consideration
  - Land tenure, rural cultures, risk-averse behavior, lack of product markets, etc.
- Project-specific analysis of forestry mitigation options
  - Establishing approaches to resolve issues of baselines, permanence, and leakage
- FORCLIMIT Project
  - Evaluation of case studies to better understand key LULUCF issues about leakage and baselines
- GCOMAP Model development

Key Concerns about Climate Change Projects

- Tests for additionality and credibility of baselines
- Estimating and controlling GHG leakage
- Monitoring and verification of GHG emissions and carbon stock
- Permanence: Duration of carbon stocks of a LULUCF project
- Sustainability concerns about LULUCF projects

The above issues, except permanence,
are of concern to all climate change projects,
although their impact varies by type of project

Leakage

- Reduced access to land, food, fuel and timber resources without offering alternatives may result in carbon leakage as people find needed supplies elsewhere
- A few pilot projects have been designed to reduce leakage
  - Multi-component projects: (CARE/Guatemala) increases fuelwood availability and agricultural productivity by encouraging agroforestry
- Significant leakage may require assessments outside the project boundary
  - Difficult if the assessment is across national boundaries

1.1 Forestry Mitigation Options In Study Countries: Key Assumptions

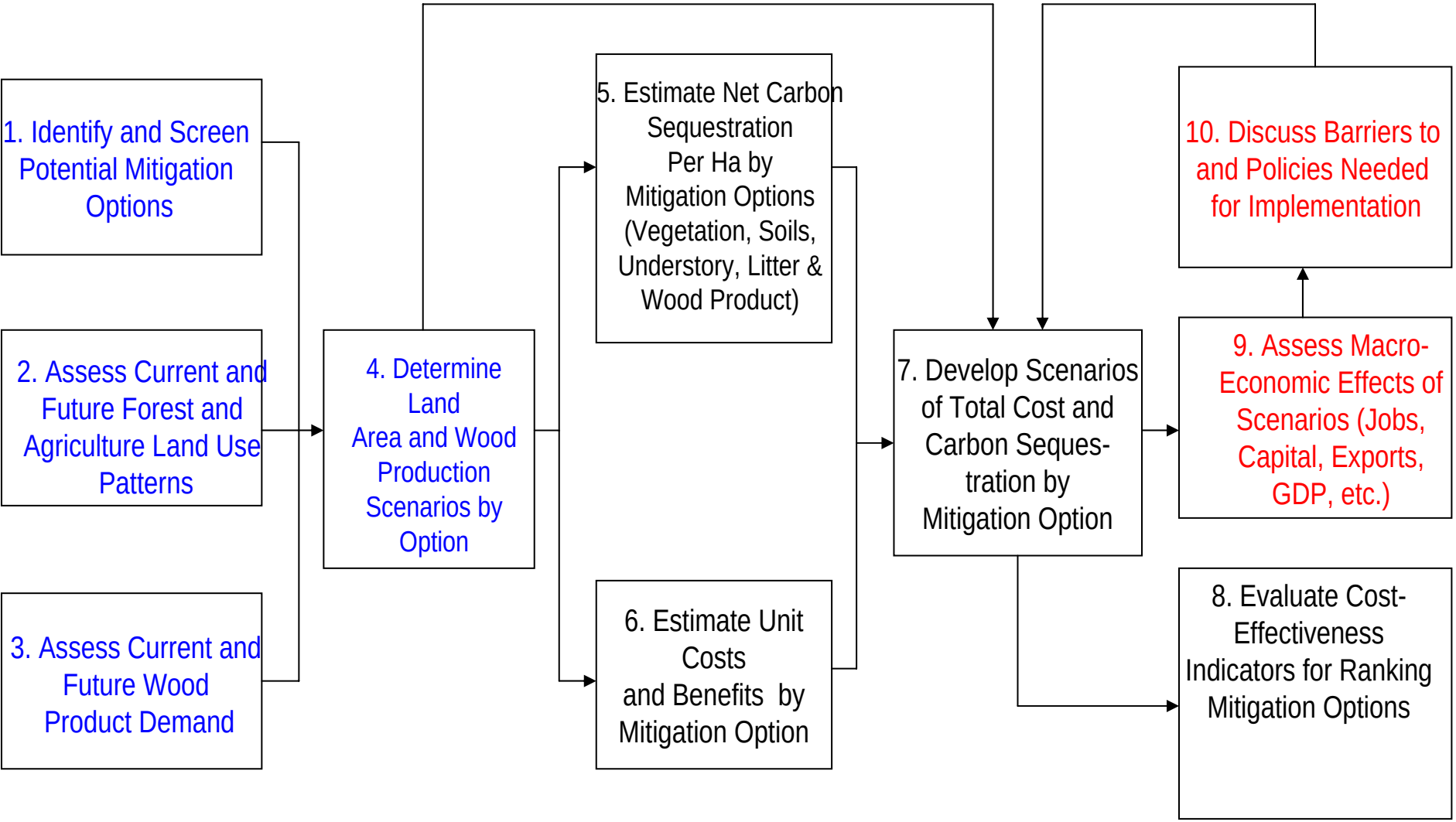
Option	Initial Cost ($/ha)	Rotation Period (yrs)	Mean Annual Increment (t C/ha/yr)
1. Short-rotation	150 – 450	7 –8	3.8 – 19.2
2. Long-rotation	450 – 700	25 – 40	1.6 – 11.1
3. Regeneration/ Management	18 – 40	40 – 80	0.8 – 3
4.Protection/ Conservation	5 – 10*		

* Excludes opportunity costs of land, which vary substantially across countries. These are accounted for in the estimates for each study country.

2. Historical land-use characteristics

Country	Total land area (‘000 ha)	Forested Area (‘000 ha)	Defrstion Rate Study Area (‘000 ha/yr)	Potential This Study (000’s ha)	Potential Trexler/Haugen (000’s ha)
Brazil	845,700	390,000	1113 – 2906	85,000	85,000
China (3 regions)	963,296	115,600	60	31,953	
India	**328,760**	**63,300**	**274**	**53,200**	**35,000**
Indo-nesia	**192,401**	**104,500**	**750-1,500**	**31,000**	**13,600**
Mexico	196,700	115,652	720	21,000	35,500
Phili-ppines	**30,000**	**5,200**	**99**	**4,400**	**8,000**
Tanzania	89,161	41,857	750	7,500	11,100
Total	2,556,857	837,593	Not Applicable	234,053	188,200

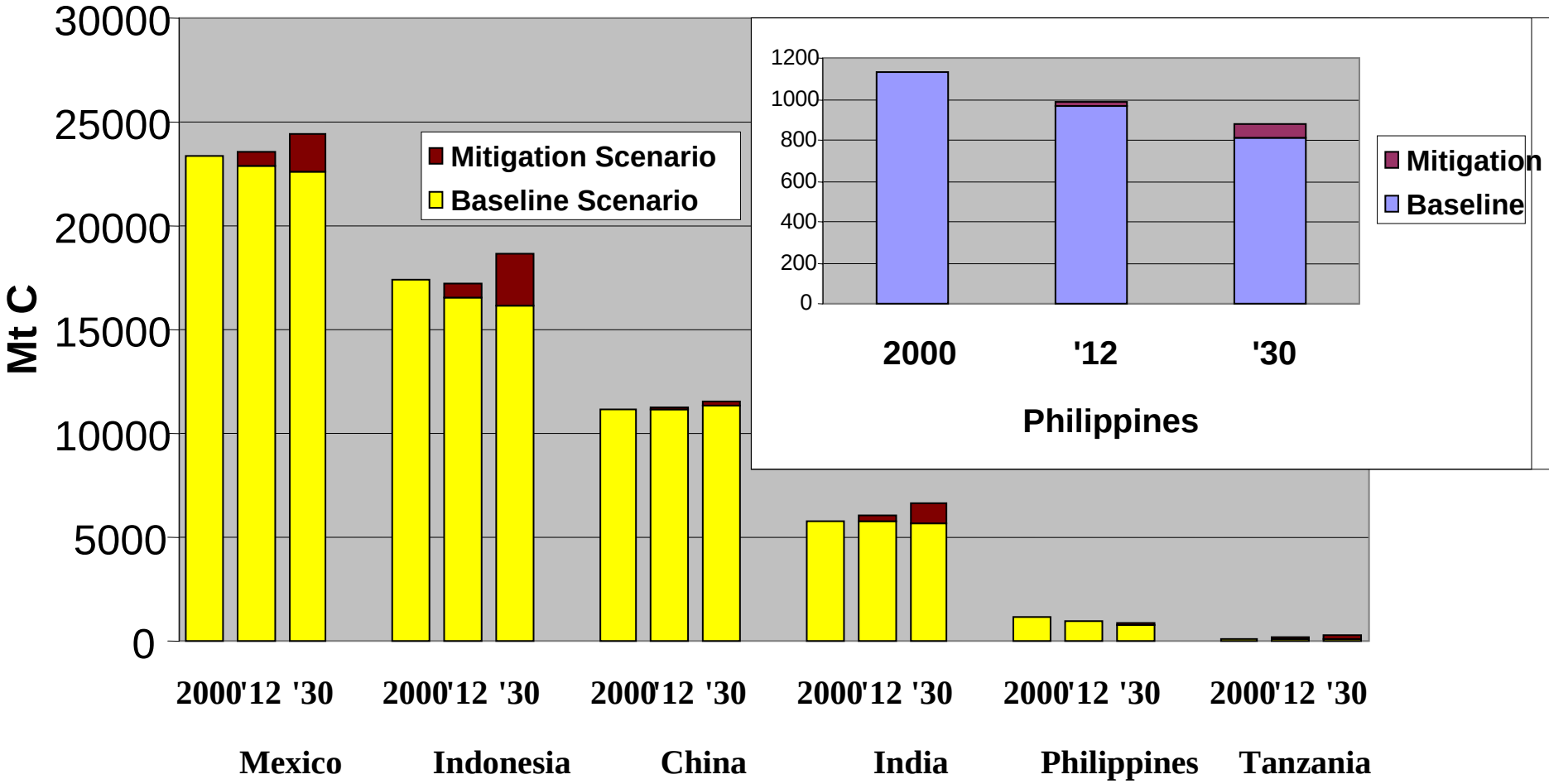
Comprehensive Mitigation Analysis Process (COMAP)



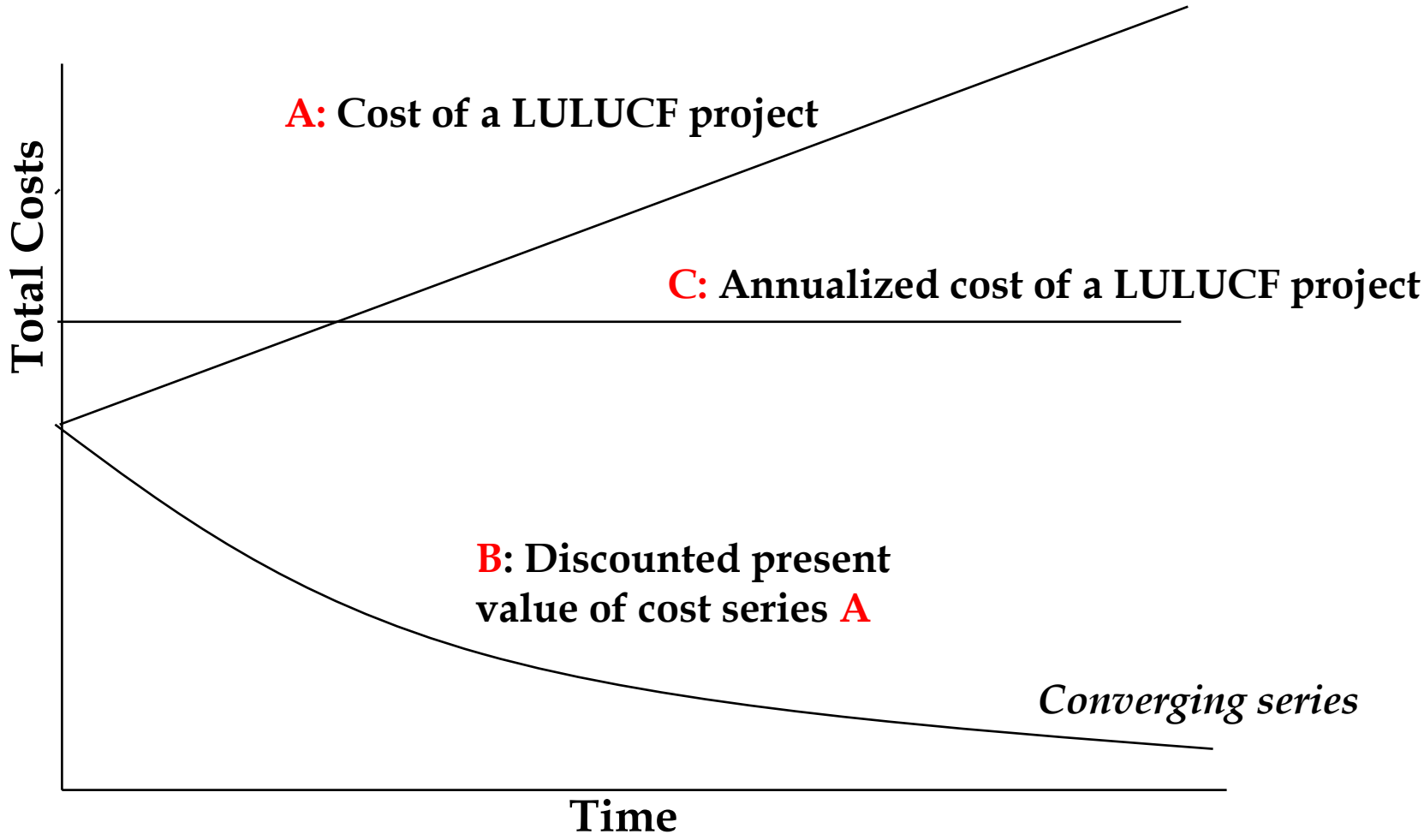
2.1 Land-use categories

	1990	1991	1992	1993	1994	1995
STEP 1.1: LAND USE ('000 Hectares)						
BASELINE SCENARIO						
Forest Land						
Tropical wet evergreen	5289.30	5286.86	5284.42	5281.81	5279.21	5261.61
Tropical semi evergreen	2575.70	2574.51	2573.32	2572.05	2570.79	2562.21
Tropical moist deciduous	23053.80	23043.17	23032.54	23021.17	23009.81	22933.09
Littoral and swamp	383.40	383.22	383.05	382.86	382.67	381.39
Tropical dry deciduous	18082.10	18073.76	18065.42	18056.51	18047.60	17987.42
Wastelands	66000	65279.52	64159.04	62600.59	61042.14	59665.16
short rotation						
Long rotation						
Natural Regen.						
Bioenergy Plantation						
Plantation Base	10230	10680	11370	12324	13278	14232
Protected Land						
Wildlife Sanctuaries						
National Parks						
Pasture land	11602	11301	11301	11301	11301	11301
Crop Land	142509	142509	142509	142509	142509	142509
Tropical thorn	1573.00	1572.27	1571.55	1570.77	1570.00	1564.76
Tropical dry evergreen	134.20	134.14	134.08	134.01	133.94	133.50
Subtropical broad leafed hill	267.80	267.68	267.55	267.42	267.29	266.40
Subtropical pine	4567.50	4565.39	4563.29	4561.04	4558.78	4543.58
Subtropical dry evergreen	1201.00	1200.45	1199.89	1199.30	1198.71	1194.71
Montane wet temperate	2581.90	2580.71	2579.52	2578.25	2576.97	2568.38
Himalayan moist temperate	2242.80	2241.77	2240.73	2239.63	2238.52	2231.06
Himalayan dry temperate	30.50	30.49	30.47	30.46	30.44	30.34
Subalpine and alpine	2027.70	2026.76	2025.83	2024.83	2023.83	2017.08
Farm and homestead garden						
TOTAL	294,352	293,751	293,291	292,655	292,019	291,383

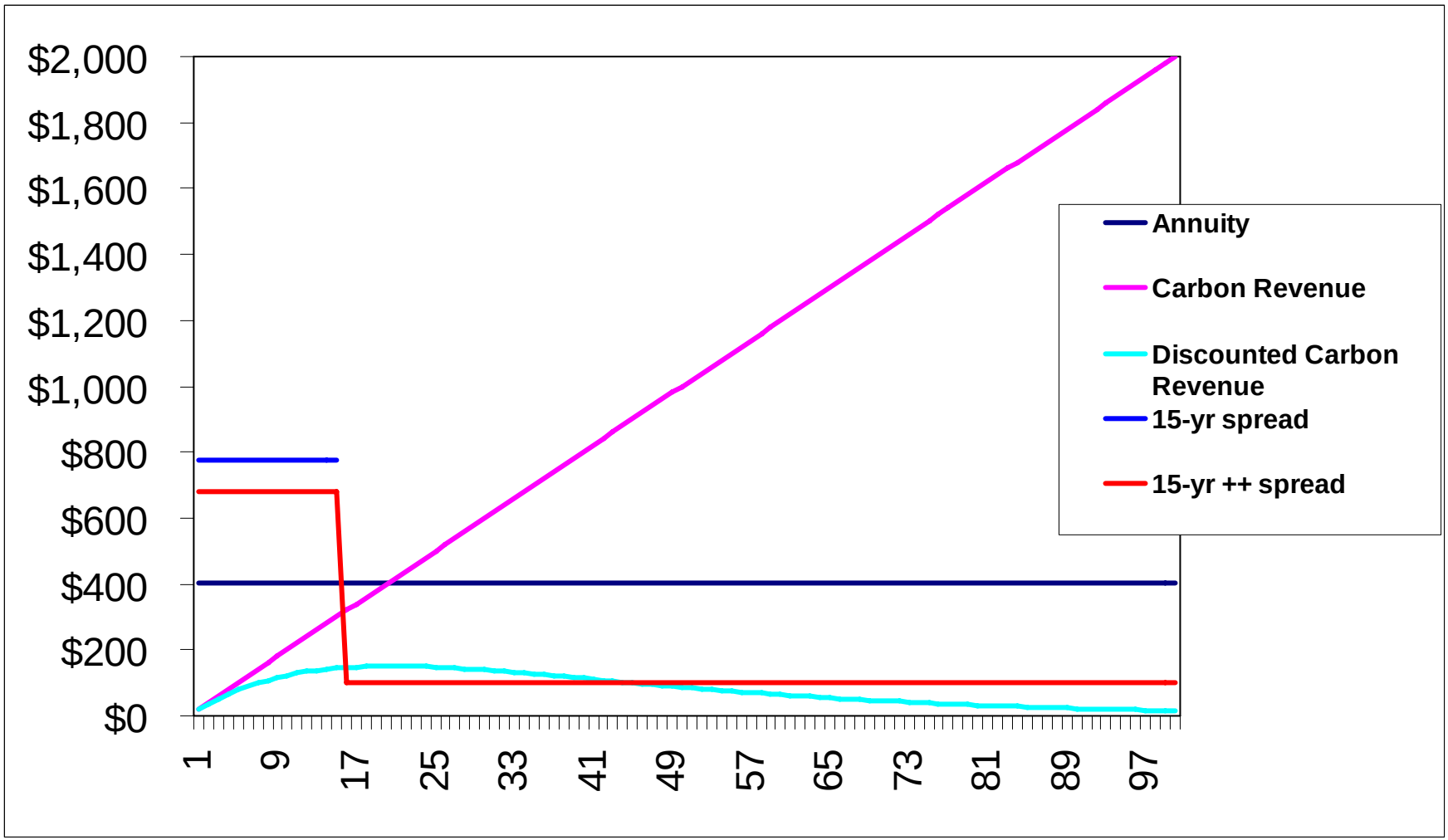
3.2 Vegetation Carbon Stock in Study Countries



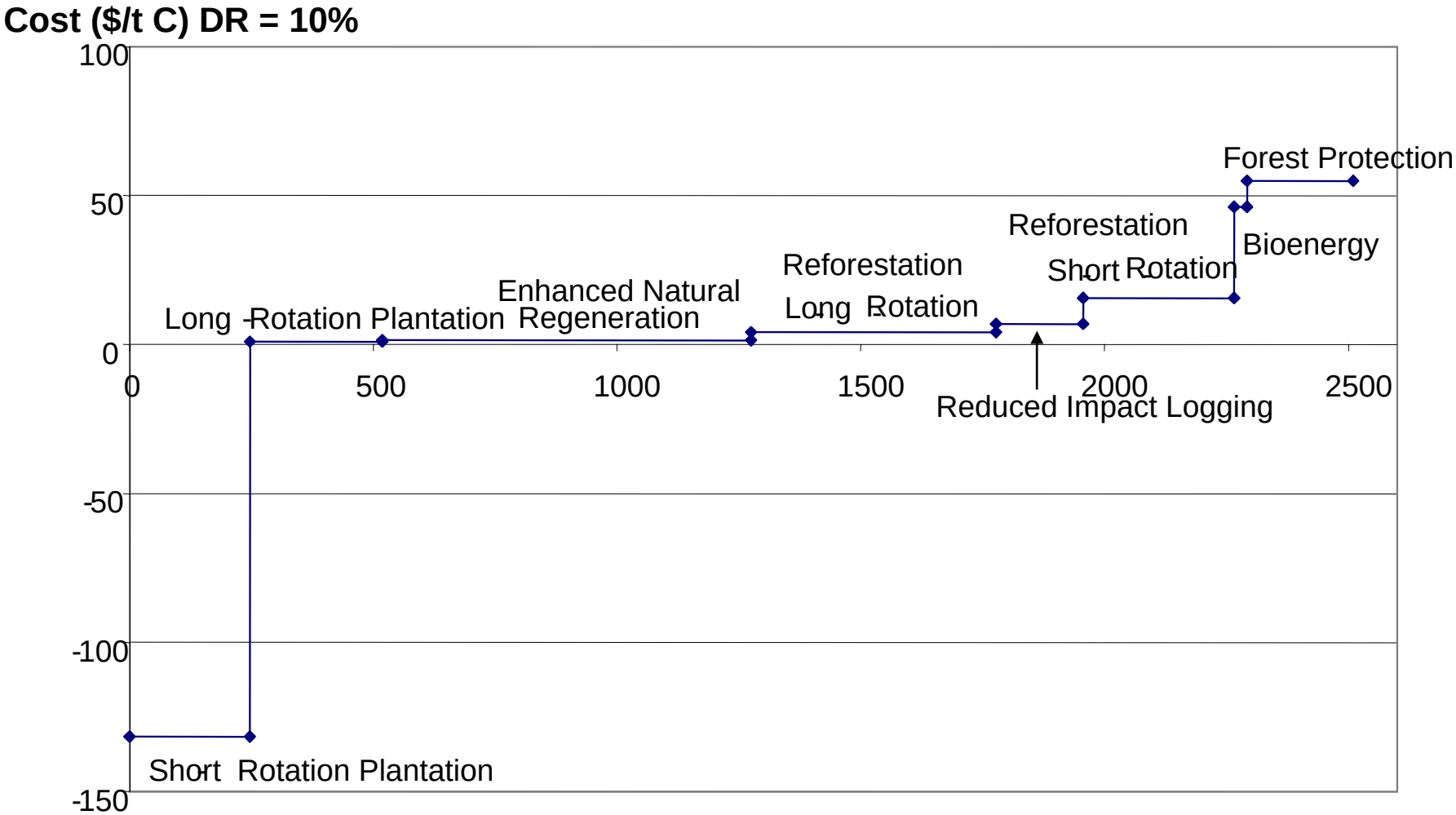
4.4 Evaluation of Project Costs



4.5 Discounting Carbon Revenue



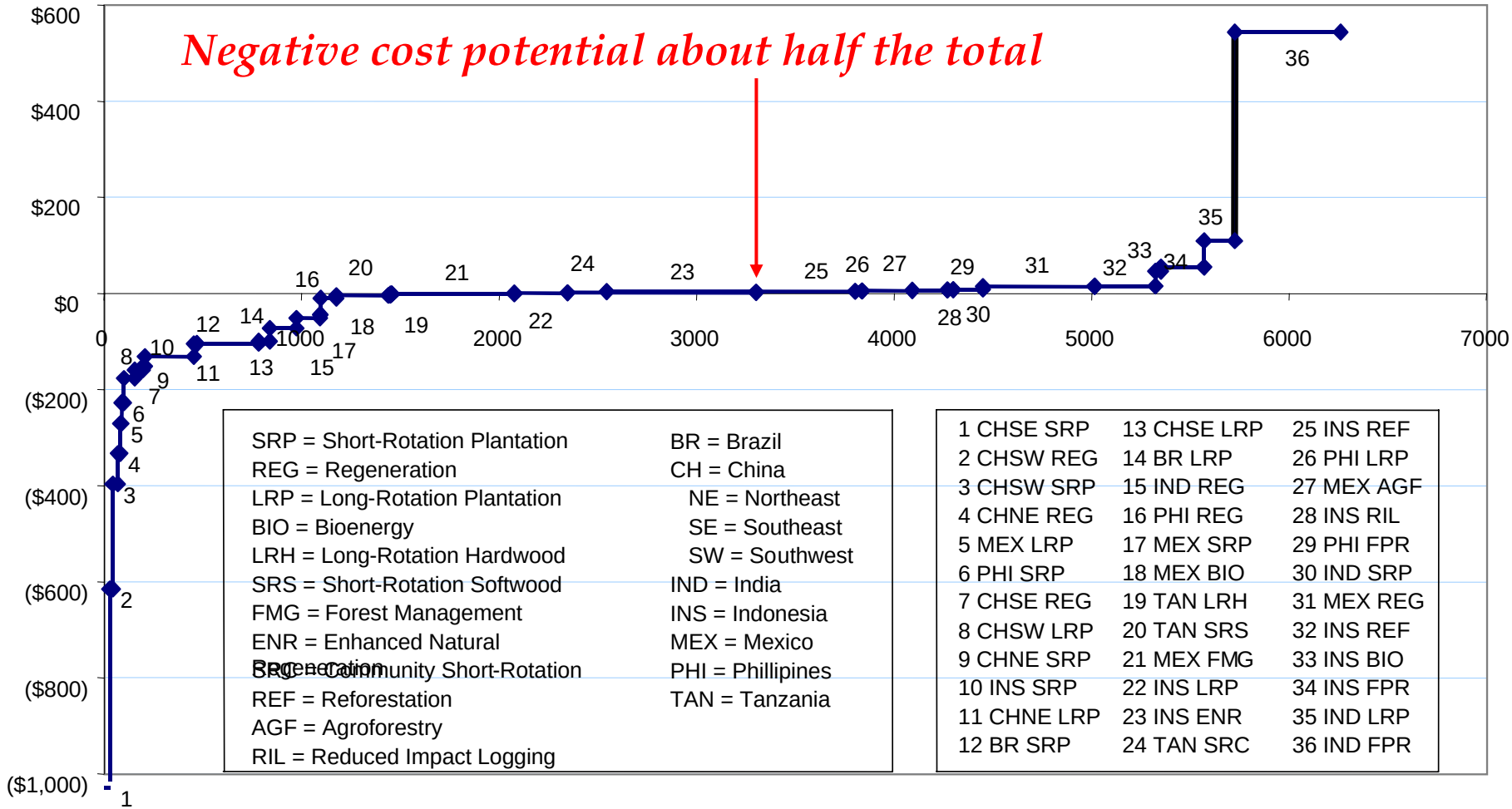
5. Forestry Mitigation Potential, Indonesia



COMAP- Forestry Mitigation Potential

(Brazil, China, India, Indonesia, Mexico, Philippines and Tanzania)

Cost ($/ t C) DR = 8-12%

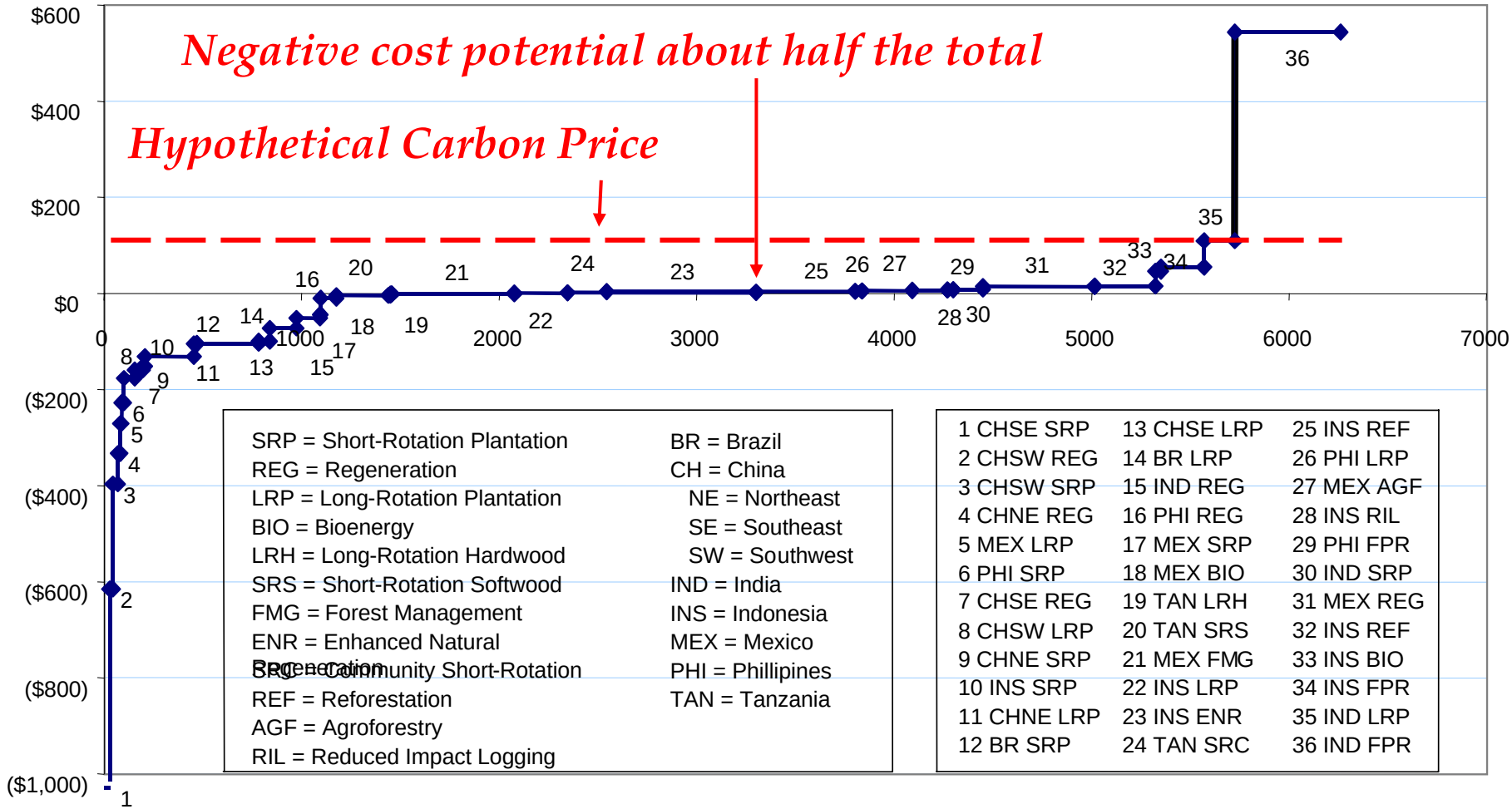


Cumulative Carbon Mitigation Potential (Mt C), 2000 -2030

5.3 Forestry Mitigation Potential

(Brazil, China, India, Indonesia, Mexico, Philippines and Tanzania)

Cost ($/ t C) DR = 8-12%



Cumulative Carbon Mitigation Potential (Mt C), 2000 -2030